Improvement of Rice Straw for Ruminant Feed Through Unconventional Alkali Treatment and Supplementation of Various Protein Sources

SNO Suwandyastuti and M Bata*

Faculty of Animal Science, Jenderal Soedirman University, Jl. Dr. Suparno, Purwokerto 53123, Indonesia
***Corresponding author email : mbata@yahoo.com**

Abstract. Various chemical treatments were conducted to increase the utilization of rice straw as feed for ruminant animals. Various sources of protein, minerals and energy should be added to improve the nutritive value of feeds. Two experiments were conducted in this study. The objective of the first experiments was to study the effect of chemical treatment on the ruminal fermentation products in cattle. Unconventional alkali treatment made from filtrate of a 10% rice hulls ash solution enriched with urea and minerals (treatment 1) increased volatile fatty acid (VFA) production, ammonia nitrogen (NH_3-N) and rumen microbial protein synthesis (MPS). The maximum values of NH_3-N production and rumen microbial protein synthesis were reached at 4 hours after incubation, while VFA was reached at 6 hours. The second experiment was conducted to study the increase of nutritive value of rice straw previously treated in experiment 1 through supplementation with various protein sources. Protein sources from the residues of vegetative oil production such as coconut, peanut and soybean showed higher responses compared to soy-sauce making residue and tofu making residue. The protein effluent production was highest (2.19 g/d) at a VFA/NH_3-N ration of 37.74 (r = 0.912). It can be recommended that protein sources from agro-industrial wastes can be used to increase the nutritive value and utilization of rice straw as ruminant feed.

Key Words: rice straw, rumen, fermentation

Introduction

Rice straw is crop residue that is an important feedstuff for ruminants in south Asia regions (Khan et al., 2005). However, this feedstuff is characterized by high content of indigestible fiber, low nutritive value and high silicate content, due to the strong hydrogen bonds in the lignocelluloses molecule. Therefore, utilization of this feedstuff was limited. Physical, chemical (Sarwar et al., 2004a,b) and biological (Sarwar et al., 1994) treatments have been used to weaken and break down ligno-cellulose bonds in crop residues, thereby increasing their feeding value for ruminants. A combined treatment with unconventional alkali and urea ammoniation successfully improves the digestibility of rice straw and dissolves most of silicate, but such treated feed is still insufficient to provide adequate protein for the ruminant animals.

The use of factory-made concentrate and mineral mixture in rice-straw-base ration has been shown to increase the nutritive value and utilization of rice straw and improve the growth performance of F.H. crossbred cattle, although deficiency of some essential minerals apparently still occurs.

The continuous availability of factory concentrates is not reliable nor easily to get in the rural villages. Therefore an alternative source that is cheap and readily available is desirable for supplementation of rice straw for ruminant feeding. The ideal protein source for ruminant feeding should be capable to support maximum rumen microbial growth, to provide adequate by pass protein with a high biological value. Rumen microbial growth is dependent on the availability of N in the form of peptides, AA and NH_3 (Russel et al., 1993). Griswold et al., (2003) reported that high microbial protein production is achieved when high rumen degradable protein is added with urea. The production of effluent protein will supply adequate available protein for ruminants.

The purpose of first trial (experiment 1) was to measure the ruminal fermentation products from rice straw based rations, of which the

straws had undergone treatment with unconventional alkali and enriched with various nutrient sources. The second trial (experiment 2) was designed to select from a number of agro-industrial by-products as protein sources, which one was the most suitable to increase the feeding value of rice straw for ruminants.

Materials and Methods

Experiment 1. The trial was carried out using a randomized complete block design by *in vitro* technique in a Shaker Water Bath Gallenkamp BKS 300-010 F. Several treatments were tested, consisted of: 5 inconvenational alkali treatments, 1 standard treatment (T_0) and 1 control (T_1). These treatments were tested on 5 levels of incubation periods: 0(T_2), 2(T_3), 4(T_4), 6(T_5), and 8(T_6) hours, respectively.

The NH_3-N production was measured by the microdiffusion method according to Conway, VFA by steam destilation method, while rumen microbial growth and microbial protein synthesis were estimated by radio-isotopic technique, using ^{32}P as the tracer (van Nevel, Demeyer and Henderickx, 1975).

Experiment 2. This trial was conducted in a randomized complete block design of 4 periods, by the technique of continuous culture fermentation in a chemostat. Each period consisted of a 7-day adaptation and a 3-day collection period. The treatments were 5 kinds of protein sources from agro-industrial waste materials and one control ration. The proteins sources to be tested were: coconut meat kernels, peanut kernels, soybean kernels, soya residues and soya-cake residues, while the control ration consisted of duplicator paper, cassava meal, vegetable oil and urea.

The production of effluent protein, NH_3-N and VFA were measured from composite samples from 3 days collection, as much as 15% of total effluent per day. The dry matter and organic matter digestibility coefficients were measured by the method of Tilley and Terry.

The inclusion of feedstuffs in the tested rations were determined on dry matter basis, consisted of: 37.5% processed rice straw, 12.5% elephant grass, 2% mineral mixture and 48% concentrate, so that all rations contained 62.5% TDN, 28% crude fiber, 12.5% crude protein and 6-8% fat.

The technique of continuous culture fermentation was carried out in 6 fermentors. Each fermentor contained 500 ml rumen fluid obtained from fistulated F.H. crossbred bull. The rumen microbes in the fermentor were fed with the tested ration of 22 gram/fermentor/day. The anaerobic condition was maintained by CO_2 gasing, while the temperature of 39-40^oC was regulated by a thermoregulator. The pH was about 6.5-6.8, and was maintained by a buffer solution with a flowrate of about 1.2-1.4 per day.

Results and Discussion

Experiment 1. This trial demonstrated that all alkali treatments as well as urea ammoniation increased the fermentation products in the rumen ($P<0.01$) which is in line with the findings of Mehrez, Orskov and Mc.Donald (1997); Leng (1990). The result was attributed to the increase in digestibility of dry matter as well as organic matter of the test ration ($P < 0.01$). Organic matter digestibility is very much related to the production of VFA's. Although the production of NH_3-N was lower than the minimum concentration required to support rumen microbial growth (3.64 mM), in this experiment the synthesis of microbial protein is reasonably high. Table 1 shows the fermentation products in the rumen using the test ration.

Table 1. Fermentation products in the rumen

Treatments	VFA (mM)	NH_3-N (mM)	MPS (Mg/L)
Standard	106.60	1.64	305
Control	195.70	1.59	318
0 hour	151.50	1.56	317
2 hours	137.30	1.35	311
4 hours	159.70	2.82	337
6 hours	152.50	2.81	327
8 hours	162.90	2.24	336

The maximum MPS was reached at 4 hours of incubation, 2.44 mM NH_3-N and 152.9 mM VFA concentrations. Refers to Satter and Slyter (1974), it is most likely that MPS would still increase, if more NH_3-N is available.

In this trial, the MPS reached its peak at about the same time with the occurrence of the peak of NH_3-N production, but that of VFA was reached at 6 hours. This indicated that the test

Table 2. VFA, NH_3-N and effluent protein production, DMDC and OMDC

Treatment	VFA (mM)	NH_3-N (mM)	Effluent Protein (g/day)	DMDC (%)	OMDC (%)
CMK	165.20	5.09	2.29	51.90	47.10
PSK	160.90	7.79	2.11	49.30	46.20
SBK	158.50	5.92	1.20	47.40	43.80
SR	140.50	4.56	1.96	44.50	34.20
SCR	161.60	3,87	2.22	45.10	42.10
C	169.80	22.7	1.27	36.00	29.2

DMDC = dry matter digestibility coefficient; OMDC = organic matter digestibility coefficient; CMK = coconut meat kernels; PSK = peanut seed kernels; SBK = soybean kernels; SR = soy-sauce making residue; SCR = tofu making residue; C = control

ration required an addition of a better protein source, which could support optimum rumen microbial growth, while part of it would escape rumen degradation and possess a high biological value, so that sufficient protein would be available post ruminally to support the ruminant's qualitative and quantitative needs. Trial 2 was carried out to test the suitability of several protein sources that meet those criteria.

Experiment 2. In this trial, the production of VFA, NH_3-N, protein effluent, dry matter digestibility coefficient (DMDC) and organic matter digestibility coefficient (OMDC) were chosen as criteria to evaluate the protein sources. Table 2 lists the data obtained in this trial.

It was demonstrated that all of the protein sources were able to produce optimum concentration of NH_3-N (ranges between 3.57-7.15 mM) as well as VFA's (about 150 mM) to support rumen microbial growth. Considering all the parameters measured, especially protein effluent production, it turned out those coconut kernels was the best protein source to be used in rice-straw based rations. Although the differences among those of different kinds of protein sources were not significant ($P > 0.05$), the differences relative to the control treatment was highly significant ($P<0.01$). The results indicated that coconut meat kernels could provide high value of readily available protein for the host animal.

The data on VFA and NH_3-N productions suggested that supplies of readily available protein as well as microbial protein were not only determined by the amount of the ruminal fermentation products, but they were more likely determined by the ratio between the two parameters (Suwandyastuti, 1998). Protein effluent production was highest at a VFA/NH_3-N ratio of 37.74. The relationship was quadratic, $Y = 838.03 + 71.7\ X – 0.95\ X^2$

($R^2 = 0.81$; $P<0.01$)

Table 2 demonstrates that coconut meat kernels caused the highest VFA production (165.2 mM), although the production of NH_3-N was moderate.

This trial also gave evidence that over production of NH_3-N was unbalance with adequate energy supply, which was unuseful and wasted. Such evidence is more serious if one considers that NH_3-N arises from degradation of feed protein. This was demonstrated by the control diet of this experiment that showed maximum NH_3-N concentration of 22.7 nM and VFA of 169.8 mM, but was unable to produce adequate protein effluent. DMDC and OMDC are also factors that determine the desired effect. The DMDC and OMDC of the control ration was the lowest among the other test rations being studied.

Conclusions

The results obtained that: (1) The addition of factory concentrates to processed rice-straw-based rations can support rumen microbial growth as well as other ruminal fermentation products; (2) Based on the results, because the availability of factory concentrate in rural villages is not continous and very expensive, therefore, other materials should be selected to provide inexpensive protein source; (3) The availability of protein effluent from natural protein source for ruminant animal was better and higher than that from urea; and (4) Among all the tested protein sources, the coconut meat kernels is the best vegetable protein from

agro-industrial waste materials to improve the nutritive value of rice straw as ruminant feed.

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